PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-333929
(43)Date of publication of application : 05.12.2000

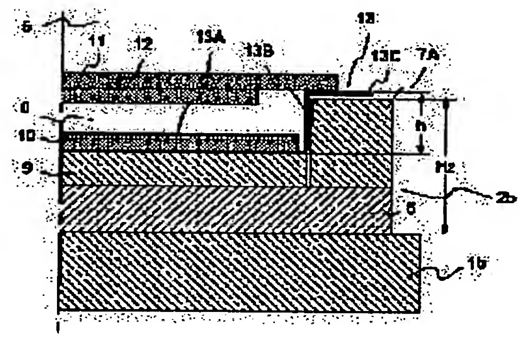
(51)Int.CI. A61B 5/055
G01R 33/421
G01R 33/385

(21)Application number : 11-145278
(22)Date of filing : 25.05.1999

(71)Applicant : HITACHI MEDICAL CORP
(72)Inventor : NAKATSU MASAYUKI
YOSHINO HITOSHI
HOSHINO SHIN

(54) MAGNETOSTATIC FIELD GENERATOR FOR MRI DEVICE AND MRI DEVICE USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a magnetostatic field generator reducing the weight of magnets and inhibiting the generation of asymmetrical eddy currents on an RF shield.
SOLUTION: This magnetostatic field generator comprises permanent magnets 1 oppositely disposed across a measurement space 5, yokes supporting them, a column supporting the yokes held at a predetermined interval to each other, and magnetic poles 2b mounted on the surfaces of the permanent magnets 1b. Each magnetic pole 2b comprises a disk-shaped base part 6 and a cylindrical first shim 7A and has a recess 8 in its center to cause magnetostatic fields from the permanent magnets 1b to concentrate in the measurement space 5. A disk-shaped eddy-current preventive material 9 is disposed in the recess 8 and an RF shield 13 made from copper foil has its bottom 13A adhesively disposed on the surface of the material 9. A magnet piece 10 or the like for adjusting the uniformity of the magnetostatic fields is disposed on the bottom 13A. Thus, the height H2 of each magnetic pole 2b is reduced by an amount equal to the thickness of the magnet piece 10 or the like to reduce the magnet weight and to inhibit deformation of the RF shield 13 thus allowing eddy currents to be generated in symmetry.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]

FB

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2003 Japan Patent Office

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to amelioration of the static magnetic field generator for magnetic resonance imaging (henceforth MRI equipment).
[0002]
[Description of the Prior Art] An example of the conventional static magnetic field generator for MRI equipments is shown in drawing 3 . In this conventional example, the permanent magnet is used for a static magnetic field generation source. Across the measurement space 5 which inserts analyte in drawing 3 , the permanent magnets 1a and 1b of a pair counter in the vertical direction, and are arranged. Magnetic pole 2a for centralizing the static magnetic field generated by permanent magnets 1a and 1b on the measurement space 5 and 2b are prepared in the side which faces the measurement space 5 of the up-and-down permanent magnets 1a and 1b. In order that magnetic pole 2a and 2b may centralize a static magnetic field on the measurement space 5 efficiently, they have a crevice in the near center section facing the measurement space 5, and consist of the ferromagnetic. It is fixed to the yokes 3a and 3b of the upper and lower sides which consist of a ferromagnetic, and permanent magnets 1a and 1b and magnetic pole 2a, and 2b are supported. Moreover, by the columns 4a and 4b of the right and left which consist of a ferromagnetic, the up-and-down yokes 3a and 3b take a gap, and are supported. Permanent magnets 1a and 1b, magnetic pole 2a, 2b, Yokes 3a and 3b, and Columns 4a and 4b form the closed circuit magnetically. Hereafter, this magnetic closed circuit is called a magnetic circuit MC.
[0003] The details cross section of the portion of permanent magnet 1b of the drawing 3 bottom is shown in drawing 4 . In drawing 4 , magnetic pole 2b consists of the disc-like base section 6, and cylinder-like 1st SIMM 7, and the inside of 1st SIMM 7 forms the crevice 8 of magnetic pole 2b. As a material of the base section 6 and 1st SIMM 7, iron material is mainly used. The disc-like eddy current prevention material 9 is arranged on the upper surface of the base section 6. It arranges in order to prevent that an eddy current generates this eddy current prevention material 9 in magnetic pole 2bs, such as the base section 6, and the multilayer (for example, 30 layers) laminating of the silicon steel of a quadrangle with a thickness of about 1mm is carried out. It pastes up with epoxy system adhesives etc. and, as a result, each silicon steel is insulated mutually.
[0004] The magnet piece or the piece 10 of iron for adjusting the static magnetic field uniformity coefficient of the measurement space 5 is arranged on the upper surface of the eddy current prevention material 9. The magnitude of a magnet piece or the piece 10 of iron is the thing of the various size length, width, and whose height are 1mm - 10mm, arranges much these side by side on the upper surface of the eddy current prevention material 9, and adjusts a static magnetic field uniformity coefficient. A magnet piece is the thing of the same quality of the material as permanent magnets 1a and 1b, and the piece of iron is the thing of the same quality of the material as magnetic pole 2a and 2b. The installation to the field of the eddy current prevention material 9 of a magnet piece or the piece 10 of iron is pasted up with epoxy system adhesives etc. Therefore, although this portion is indicated by disc-like in drawing 4 , only the portion which not disc-like but the magnet piece or the piece of iron has pasted up has projected the actual configuration from the surface of the eddy current prevention material 9, and other portions have become space.
[0005] Although the static magnetic field which had uniform reinforcement and uniform directivity in the measurement space 5 spatially and in time is made by the above-mentioned magnetic circuit MC, in order to obtain a magnetic resonance (MR) image, (RF RF) exposure coil 11, a gradient coil 12, etc. are needed. RF exposure coil 11 irradiates a pulse-like electromagnetic wave at analyte in order to excite the magnetic moment of the proton in analyte magnetically, and a gradient coil 12 is for giving positional information to MR signal. These RF exposure coils 11 and gradient coils 12 are arranged to a permanent magnet 1 and a magnetic pole 2 at the side near the measurement space 5, as shown in drawing 3 and drawing 4 . Moreover, it may be arranged in the crevice 8 of a gradient coil 12.
[0006] If an electromagnetic wave is irradiated with RF exposure coil 11 at analyte, since a lot of electromagnetic waves will be absorbed by the surrounding magnetic circuit MC in addition to

analyte, the exposure effectiveness to the analyte of an electromagnetic wave falls. In order to prevent decline in this exposure effectiveness, the RF (RF) shield 13 is arranged in the space between the gradient coils 12, the magnet pieces, or the pieces 10 of iron which have been arranged by approaching RF exposure coil 11. This RF shield 13 is the electric good conductor of 10 micrometers of thickness numbers, and is the collar-head bowl-like object 13. Copper foil with a thickness of about 30 micrometers is used for the material of the RF shield 13. The thin sheet (0.2-0.3mm thickness) which consists of insulating materials, such as a vinyl chloride, is stuck on both the surfaces of copper foil to serve both as reinforcement and an insulation. If too thick, in order for the yield of an eddy current to increase and to do a bad influence to an inclination magnetic field about the thickness of copper foil, in the limit where structure is maintainable, the thinner one is good. In the present condition, copper foil with a thickness of dozens of micrometers is used.
[0007] The collar-head bowl-like object of the RF shield 13 consisted of pars-basilaris-ossis-occipitalis 13A which consists of a disk of copper foil, body 13B which rounded off the copper foil sheet and was connected, and flange 13C which made the circular hole in the copper foil disk of a major diameter, and solder etc. has connected connection of each member. although copper foil and an insulation sheet have 3 layer structures -- the immobilization between both -- adhesion -- or -- putting -- it is carried out.
[0008] Support of the RF shield 13 is performed in pars-basilaris-ossis-occipitalis 13A and flange 13C. It is ****ed and attached about pars-basilaris-ossis-occipitalis 13A, two or more places are supported with a stanchion 14, the long DISUTANTO piece (henceforth D piece) A15, and the short D piece B16, and it is inserted and supported about flange 13C with 1st SIMM 7 and RF exposure coil 11 of magnetic pole 2b. With RF exposure coil 11 etc., pars-basilaris-ossis-occipitalis 13A of the RF shield 13 takes a gap, is ****ed and attached with the D piece A15 and the D piece B16, and is attached in the base section 6 with the stanchion 14. The insulating material is used for materials of the D piece A15 and the D piece B16, such as stainless steel, by the material of the stanchion 14 with a screw thread.
[0009] In order to prevent decline in RF exposure effectiveness produced when the electromagnetic wave irradiated from RF exposure coil 11 is absorbed by the RF shield 13, it is necessary to secure widely the distance between the RF shield 13 and RF exposure coil 11 as much as possible. In order to secure this distance, the depth of the crevice 8 of a magnetic pole 2 where the RF shield 13 and a gradient coil 12 are arranged was made as deep as possible.
[0010]
[Problem(s) to be Solved by the Invention] However, with the above-mentioned conventional structure, since the thickness (namely, thickness which doubled 1st SIMM 7 and the base section 6) H1 of the magnetic pole 2 whole became thick when the depth of the crevice 8 in a magnetic pole 2 becomes deep, the distance between up-and-down permanent magnet 1a and 1b became large, magnetic AUW increased, and it had led to decline in magnetic field generating effectiveness. For this reason, without reducing the exposure effectiveness of RF exposure coil 11, the first purpose in this invention is improving magnetic field generating effectiveness, when thickness of a magnetic pole 2 is made thin, and only that part makes small distance between up-and-down permanent magnet 1a and 1b and reduces magnetic AUW.
[0011] Moreover, the phenomenon of mechanical rigidity being weak and curtaining in convex in portions other than the supporting point at the bottom in spite of supporting two or more places of the disc-like pars-basilaris-ossis-occipitalis 13A since the RF shield 13 of structure consists of thin copper foil of about 10 micrometers of thickness numbers can see conventionally. Thus, when pars-basilaris-ossis-occipitalis 13A of the up-and-down RF shield 13 became convex partially and it is based on the center position of the measurement space 5, pars-basilaris-ossis-occipitalis 13A of the up-and-down RF shield 13 will be arranged asymmetrically. When an electromagnetic wave is irradiated with RF exposure coil in the condition that the RF shield 13 is such unsymmetrical arrangement or an inclination magnetic field is impressed to a gradient coil 12, the eddy current asymmetrically distributed on the up-and-down RF shield 13 will occur, it may originate in this eddy current and a ghost and the artifact may be generated in MR imaging.
[0012] For this reason, the second purpose in this invention is preventing the eddy current which makes arrangement of the RF shield 13 it is stable and symmetrical, and is asymmetrically

distributed on RF shield occurring.
[0013]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, a static magnetic field generator for MRI equipments of this invention arranges RF shield which consists of an electric good conductor between said static magnetic field generating means and said magnet piece, or a ferromagnetic piece in a static magnetic field generator for MRI equipments possessing a static magnetic field generating means supply a uniform static magnetic field of magnetic-field-strength distribution to measurement space, and a magnet piece or a ferromagnetic piece for adjusting magnetic homogeneity of measurement space (claim 1).
[0014] As opposed to RF shield which consists of an electric good conductor being conventionally arranged in elegance between measurement space and a magnet Katamata ferromagnetic piece for homogeneity magnetic field adjustment with this configuration Since RF shield which consists of an electric good conductor is arranged between a magnet piece for a static magnetic field generating means and magnetic homogeneity adjustment, or a ferromagnetic piece, RF shield will be conventionally arranged from a center of measurement space in a location of a magnet piece or a ferromagnetic piece distant by thickness (this thickness is hereafter set to t) compared with elegance. for this reason, a static magnetic field generating means is in the same location -- if it becomes, 2t only in thickness can extend measurement space, and let measurement space be the same size -- if it becomes, only a part of thickness t can make a static magnetic field generating means approach measurement space Since distance between magnets becomes [in the case of the latter] small in 2t only in thickness, it can contribute to reduction of magnetic AUW and magnetic field generating effectiveness can be improved.
[0015] In a static magnetic field generator for MRI equipments of this invention, further said static magnetic field generating means A magnetic pole which consists of a ferromagnetic of a pair arranged at a side which faces measurement space of a permanent magnet in order to centralize efficiently a static magnetic field which a permanent magnet of a pair countered and arranged across measurement space and a permanent magnet generate on measurement space, A yoke of a pair which supported a permanent magnet and a magnetic pole and has been arranged on the outside of a permanent magnet, Take a gap, support a yoke and it consists of a permanent magnet, a magnetic pole, and a yoke and a column which forms a magnetic closed circuit. Said magnet piece or a ferromagnetic piece is arranged at a side which faces measurement space of a magnetic pole, and said RF shield is pinched between a magnetic pole, said magnet piece, or a ferromagnetic piece, and it is arranged (claim 2).
[0016] With this configuration, a static magnetic field generating means is the thing of a method which a permanent magnet was made to counter, both sides of measurement space are countered, a magnetic pole is arranged, and RF shield is pinched and arranged between a magnetic pole, a magnet piece, or a ferromagnetic piece. Consequently, the effect as a case of claim 1 that it is the same since RF shield separates only thickness [from a center of measurement space] t from elegance conventionally and it is arranged is acquired. Furthermore, since RF shield is pinched between a magnetic pole, a magnet piece, or a ferromagnetic piece, it is lost that an electric good conductor of RF shield deforms, it is lost that an unsymmetrical eddy current etc. occurs to RF shield at the time of RF exposure from RF exposure coil or inclination magnetic field impression, and it contributes to improvement in image quality of MR imaging.
[0017] In a static magnetic field generator for MRI equipments of this invention, eddy current prevention material is further provided in a side by which said magnetic pole faces measurement space, and said RF shield is arranged between a magnet piece or a ferromagnetic piece eddy current prevention material and the first half (claim 3). With this configuration, since eddy current prevention material is attached in order to prevent generating of an eddy current on the surface of a magnetic pole, RF shield is arranged between this eddy current prevention material, a magnet piece, or a ferromagnetic piece. Therefore, the same effect as a case of claim 2 is acquired also in this case, and the above-mentioned 1st and the 2nd above-mentioned purpose can be attained.
[0018] MRI equipment of this invention possesses the above-mentioned static magnetic field generator for MRI equipments as a static magnetic field generator (claim 4). With MRI equipment of this configuration, while reducing AUW of a magnet of a static magnetic field generator and

improving magnetic field generating effectiveness, improvement in image quality of MR imaging can be aimed at by generating prevention of an unsymmetrical eddy current to RF shield.
[0019]
[Embodiment of the Invention] Hereafter, an accompanying drawing explains the static magnetic field generator for MRI equipments of this invention. Drawing 1 and drawing 2 show one example of the static magnetic field generator for MRI equipments of this invention. Drawing 1 is the whole static magnetic field generator block diagram, and drawing 2 is the important section expanded sectional view. Since the static magnetic field generator of this example is mostly constituted by the symmetry form in the vertical direction centering on measurement space, the expanded sectional view in the right half of a bottom magnet is shown in drawing 2 .
[0020] In drawing 1 , the static magnetic field generator for MRI equipments consists of permanent magnets 1a and 1b which countered in the vertical direction and have been arranged across the measurement space 5, yokes 3a and 3b of the upper and lower sides which consist of ferromagnetics, such as iron which supports these permanent magnets 1a and 1b, and columns 4a and 4b of the right and left which consist of ferromagnetics, such as iron which takes a gap and supports Yokes 3a and 3b. Magnetic pole 2a which consists of ferromagnetics, such as iron, and 2b are attached in the opposed face side of the up-and-down permanent magnets 1a and 1b, and the role which centralizes the static magnetic field which the up-and-down permanent magnets 1a and 1b generate on the measurement space 5 is borne. Permanent magnets 1a and 1b, magnetic pole 2a, 2b, Yokes 3a and 3b, and Columns 4a and 4b form the magnetic circuits MC including the measurement space 5 equivalent to an air gap with such a configuration.
[0021] The magnet portion except yoke 3b of drawing 1 and Columns 4a and 4b is shown in drawing 2 . In drawing 2 , magnetic pole 2b arranged at the upper surface side of permanent magnet 1b consists of the disc-like base section 6 which consists of ferromagnetics, such as iron, and 1st SIMM 7A of the shape of a cylinder which consists of ferromagnetics, such as iron. Only the part of thickness t of the ferromagnetic pieces 10, such as a magnet piece for the height of this 1st SIMM 7A to adjust magnetic homogeneity compared with elegance conventionally or iron, is made short. For this reason, also as for the height H2 of the whole magnetic pole 2b, only thickness t is short from the height H1 of the magnetic pole of elegance conventionally. Inside magnetic pole 2b, the circular crevice 8 made from the base section 6 and 1st SIMM 7A is. In this crevice 8, the ferromagnetic pieces 10, such as the disc-like eddy current prevention material 9, the RF shield 13 of a collar-head bowl-like object, a magnet piece, or iron, are arranged.
[0022] The eddy current prevention material 9 is arranged on the upper surface of the base section 6, and prevents that an eddy current occurs in the base section 6. This eddy current prevention material 9 is what carried out the laminating of the silicon steel of a quadrangle (a length of one side before or after 100mm) with a thickness of about 1mm, and was made disc-like, and it is pasted up and insulated with epoxy system adhesives etc. between each boards. The thickness of a laminate is about dozens of mm.
[0023] The RF shield 13 intercepts that the electromagnetic wave irradiated from RF exposure coil 11 is absorbed by magnetic pole 2b, and consists of copper foil of 10 micrometers of thickness numbers (usually before or after 30 micrometers). Other materials may be used for it as long as this material is an electric good conductor not only copper foil but thin. The RF shield 13 consists of disc-like pars-basilaris-ossis-occipitalis 13A, body 13B, and flange 13C, and each part is connected with solder etc. The insulation sheet with which copper foil consists of insulating materials, such as a vinyl chloride, on the surface of both sides for an insulation and configuration maintenance is stuck. The thickness of an insulation sheet is about 0.2-0.3mm. The shielding effect of the RF shield 13 is so large that height h of body 13B is high.
[0024] In drawing 2 , pars-basilaris-ossis-occipitalis 13A of the RF shield 13 is arranged so that it may stick to the upper surface of the eddy current prevention material 9. You may paste up with adhesives between the inferior surface of tongue of pars-basilaris-ossis-occipitalis 13A of the RF shield 13, and the upper surface of the eddy current prevention material 9. The ferromagnetic pieces 10, such as a magnet piece or iron, are pasted up and laid in the upper surface of pars-basilaris-ossis-occipitalis 13A of the RF shield 13. The ferromagnetic pieces 10, such as a magnet piece or iron, have a various size, it consists of the cube which is usually 1-10mm, and the installation location is

decided according to the uniformity coefficient adjustment specification of a static magnetic field. The thickness of the layer of the ferromagnetic pieces 10, such as a magnet piece or iron, is not uniform like the above-mentioned, there are a portion in which a magnet piece etc. exists, and a portion not existing, and height of this layer, such as a magnet piece, is also various, and it is an uneven excessive layer. Therefore, this thickness t will be decided by the thickest thing of the ferromagnetic pieces 10, such as a magnet piece or iron.

[0025] In this example, the structure of the permanent magnets 1a and 1b which constitute a magnetic circuit MC, Yokes 3a and 3b, Columns 4a and 4b, magnetic pole 2a, the base section 6 of 2b and 1st SIMM 7, the eddy current prevention material 9, RF exposure coil 11, and a gradient coil 12 is fundamentally [as the conventional static magnetic field generator shown in drawing 3] the same. according to this example -- the size configuration of the RF shield 13 -- as [drawing 4] -- carrying out (height h of the RF shield 13 being maintained) -- Since only the part of thickness t of the ferromagnetic pieces 10, such as a magnet piece or iron, can reduce the thickness of 1st SIMM 7 and it can reduce as the magnetic pole 2 whole only for thickness t minutes of the ferromagnetic pieces 10, such as a magnet piece or iron, only the part can reduce the weight of a magnetic pole 2.

[0026] Therefore, static magnetic field reinforcement [in / at this example / the distance between up-and-down magnetic pole 2a and 2b, and the measurement space 5], And improvement in magnetic field generating effectiveness can be aimed at by shortening the distance between up-and-down permanent magnet 1a and 1b twice only by 2t of the thickness of the ferromagnetic pieces 10, such as a magnet piece or iron, and reducing magnet AUW (especially reduction of magnetic pole weight), without changing the size of magnetic field homogeneity space.

[0027] Moreover, when permanent magnets 1a and 1b have been arranged in the same location, it is also possible to extend the measurement space 5 by the thickness of the ferromagnetic pieces 10, such as a magnet piece or iron.

[0028] Moreover, it becomes what has symmetrical distribution of the eddy current generated on the RF shield 13 since it is lost that pars-basilaris-ossis-occipitalis of RF shield 13 13A bends since pars-basilaris-ossis-occipitalis of RF shield 13 13A will be put in respect of the strong metal of rigidity in this example and it will fix and it will become symmetrical [that arrangement of the RF shield 13 is stabilized] at the upper and lower sides. Consequently, it can reduce that the eddy current asymmetrically distributed on the RF shield 13 occurs.

[0029] In the above-mentioned example, although the static magnetic field generator which countered in the vertical direction and has arranged permanent magnets 1a and 1b was explained, this invention is not limited to this, but across the measurement space 5, may counter right and left horizontally and may arrange permanent magnets 1a and 1b.

[0030] Moreover, the magnet which consists of the superconduction coil or usual state conduction coil which wound around the coiled form the wire rod which is not limited to a permanent magnet but consists of a superconducting material or a usual state conduction material is sufficient as the magnet as a static magnetic field generating means of this invention.

[0031] The static magnetic field generator of this invention can be applied as a static magnetic field generator of MRI equipment like the conventional static magnetic field generator. With the MRI equipment which applied the static magnetic field generator of this invention, effects, such as reduction of the cost by reduction of magnetic AUW, and a ghost of MR imaging, improvement in the image quality by removal of the artifact, are acquired.

[0032]

[Effect of the Invention] Since thickness of a magnetic pole 2 can be made small in the static magnetic field generator for MRI equipments according to this invention, without shortening the distance between RF exposure coil 11 and the RF shield 13 as explained above, the distance between up-and-down permanent magnet 1a and 1b can be shortened, and reduction of magnetic AUW and improvement in the magnetic field generating effectiveness accompanying it can be aimed at.

[0033] Moreover, since arrangement of the RF shield 13 can be made [stability and] symmetrical by crowding and fixing on both sides of the RF shield 13 in the field of a strong rigid metal according to this invention, the ghost and artifact of MR image generated when an eddy current was asymmetrically distributed on the RF shield 13 are removable.

[Translation done.]

THIS PAGE BLANK (USPTO)

CLAIMS

[Claim(s)]

[Claim 1] A static magnetic field generator for MRI equipments characterized by to arrange a RF shield which consists of an electric good conductor between said static magnetic field generating means and said magnet piece, or a ferromagnetic piece in a static magnetic field generator for MRI equipments possessing a static magnetic field generating means to supply a uniform static magnetic field of magnetic-field-strength distribution to measurement space, and a magnet piece or a ferromagnetic piece for adjusting magnetic homogeneity of measurement space.

[Claim 2] In a static magnetic field generator for MRI equipments according to claim 1 said static magnetic field generating means A magnetic pole which consists of a ferromagnetic of a pair arranged at a side which faces measurement space of a permanent magnet in order to centralize efficiently a static magnetic field which a permanent magnet of a pair countered and arranged across measurement space and a permanent magnet generate on measurement space, A yoke of a pair which supported a permanent magnet and a magnetic pole and has been arranged on the outside of a permanent magnet, Take a gap, support a yoke and it consists of a permanent magnet, a magnetic pole, and a yoke and a column which forms a magnetic closed circuit. Said magnet piece or a ferromagnetic piece is a static magnetic field generator for MRI equipments characterized by being arranged at a side which faces measurement space of a magnetic pole, and arranging said RF shield between a magnetic pole, said magnet piece, or a ferromagnetic piece.

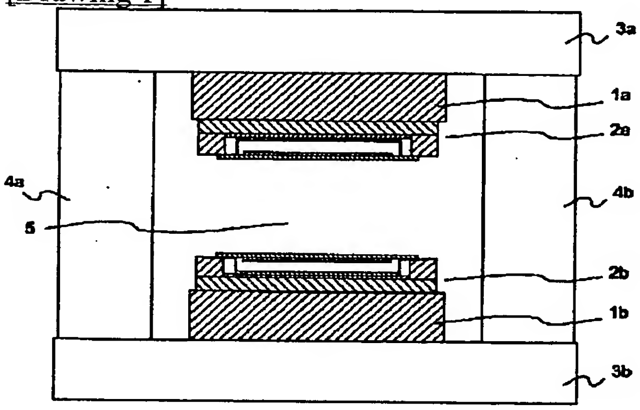
[Claim 3] A static magnetic field generator for MRI equipments characterized by providing an eddy current inhibitor in a side by which said magnetic pole faces measurement space in a static magnetic field generator for MRI equipments according to claim 2, and arranging said RF shield between an eddy current inhibitor, said magnet piece, or a ferromagnetic piece.

[Claim 4] MRI equipment characterized by providing a static magnetic field generator for MRI equipments according to claim 1 to 3 as a static magnetic field generator.

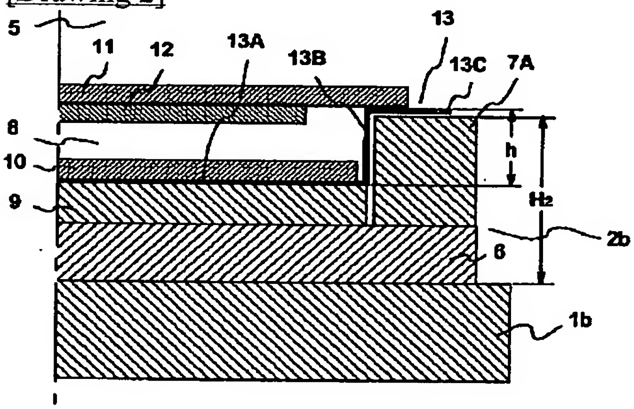
[Translation done.]

DRAWINGS

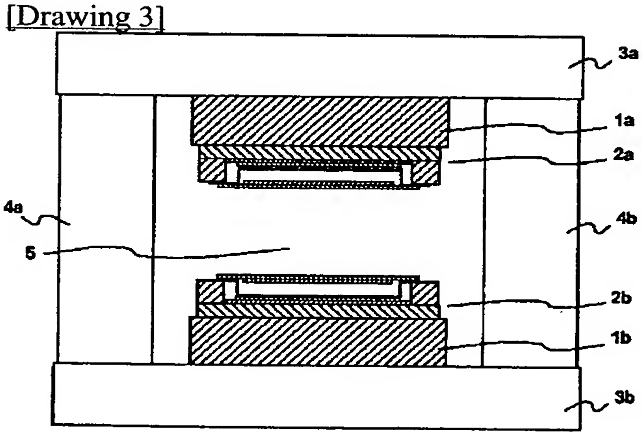
[Drawing 1]



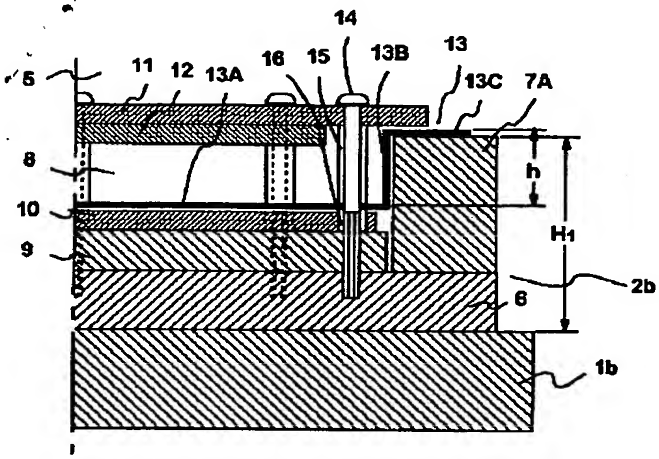
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]